Symbiosis of Neuro Fuzzy System and Genetic Algorithm in the Diagnosis of Cardiovascular Disease: A Review

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ABSTRACT

Cardiovascular disease is the disease related to heart, arteries etc. Data related to various human parameters like blood pressure, age, cholesterol, obesity etc. can be analysed by effective application of Data Mining techniques. Data mining is a technique of analysing large databases to find out various useful patterns. Application of data mining techniques will be very much helpful to not only to the medical professionals but also to an individual in the prediction of cardiovascular diseases because of its accuracy and reduction in cost. In this work we will apply Neuro-Fuzzy System to the available data for prediction of the cardiovascular disease and training will be done using back propagation algorithm and the weight optimization will be done by Genetic Algorithm. The neuro-fuzzy model combines the neural network adaptive capabilities and the fuzzy logic reasoning approach for prediction of cardiovascular disease. The proposed system is going to produce an intelligent system with good accuracy.
Keywords:- Data Mining, Neuro-Fuzzy System, Genetic Algorithm, Back-propagation

1. INTRODUCTION

In todays' changed lifestyle, cardiovascular diseases are playing villainous role and heading towards a major cause of death. Cardiovascular disease (CVD) is a major cause of morbidity and mortality in the modern society. Diagnosis of cardiovascular disease using various Medical tests is an important but complicated task and becoming costlier day by day. Hence a powerful tool in the prediction of heart disease with lower cost has become the need of time. Tons of data about various human parameters are available on the internet. This data can be analyzed by effective application of Data Mining techniques. Data mining is a technique of analyzing large data to find out various patterns which can be proved very much useful in prediction of cardiovascular disease without undergoing any major medical examinations or tests. As many of the symptoms of the patient leads to confusion about the exact cause of disorder, medical professionals will also find out this system as a reliable tool in diagnosis. Neural network is widely applied in pattern recognition in large datasets and are effective due to its adaptive capabilities just like the biological neurons in human brain. Fuzzy Systems is used for precise prediction in different application domains. The combination of neuro fuzzy system combines advantages of neural network such as leaning ability and fuzzy systems reasoning ability which makes it more powerful. Genetic Algorithms is used to form Fuzzy Systems which introduce the learning and adaptation capabilities. All doctors may not be equally skilled in every sub specialty and they are in many places can be in state of confusion in analyzing and predicting the accurate diagnosis. A system for automated medical diagnosis would enhance medical care and reduce costs. This system will not only prove helpful to medical professionals but it would give patients a warning about the probable presence of cardiovascular disease even before he\she visits a hospital or goes for costly medical check-ups. The system implementation will be done using Matlab.

2. PROPOSED METHODOLOGY

The objective of this research is to create an intelligent & cost effective system which will overcome the limitations of existing system and improve its performance. A way to enhance the performance of a model that combines neural network and fuzzy logic for classification is the application of genetic algorithm to improve the learning of neuro-fuzzy system. Various methods have been used for the detection of a potential medical problem. Thus, a reliable method is required. The neuro –fuzzy system (NFS) model which combines the adaptability of fuzzy inputs with neural network is used to accurate prediction. And this kind of network is more efficient than the simple neural network. Neuro fuzzy systems are fuzzy systems which use ANN's theory in order to determine their properties like fuzzy sets and fuzzy rules by processing data samples. The main objective of this research is to develop an Intelligent Cardiovascular Disease

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Prediction system. Here the dataset related to the cardiovascular disease is provided to the neuro-fuzzy system. The dataset consist of the patients symptoms of cardiovascular disease. It consists of cardiovascular disease patients' information. This Cleveland databases are publicly available.
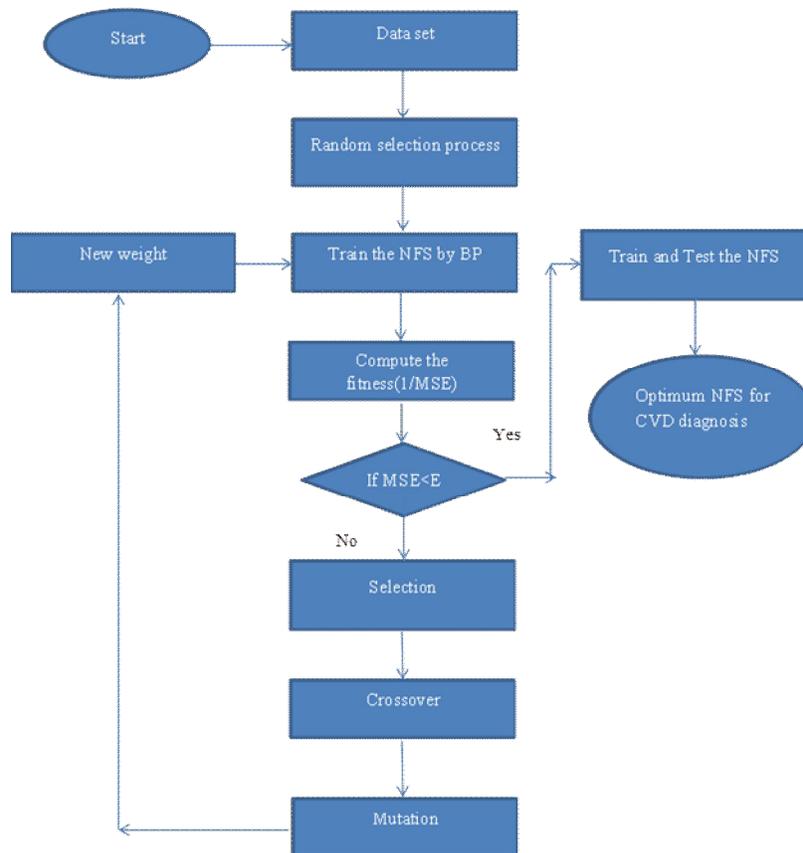

Figure 1: Flow chart of proposed work

The process of Neuro-Fuzzy with GA presented below:

1. Initialized the process of predicting Cardiovascular Disease.

2. Extract the patient's details from dataset.

3. Assign the input and output to NFS.

4. Selection process start with assign weight randomly to each attributes.

5. Training is done using Back-propagation.

6. Compute output values.

7. Compute fitness using

$$\text{Mean Square Error} = \frac{\sum (\text{Outputs - Targets})^2}{\text{Number of samples}}$$

8. If MSE is less than error then go to step 10, otherwise go to step 9.

9. Select the parents and apply crossover and mutation.

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10. Train NF with selected connection weights.

11. Study the performance of test data.

2.1 Neuro-Fuzzy System

A neuro-fuzzy system has one input and one output layers, and three layers which is called as hidden layer that represent input membership functions and fuzzy rule sand output membership function. A neuro-fuzzy system has total five layers [8]-[2].
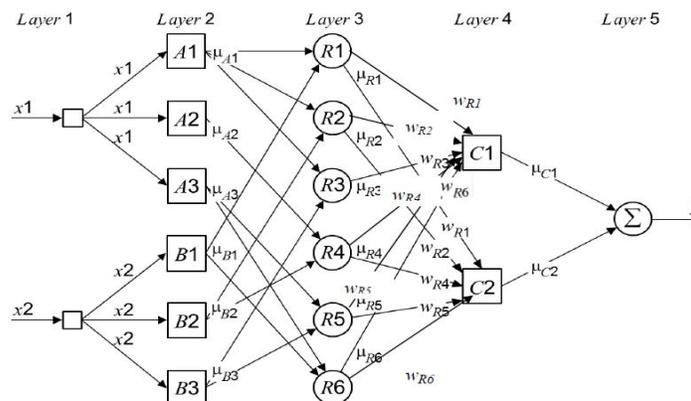

Figure 2: Architecture of the neuro-fuzzy system

Layer 1

This layer is called as an input layer in which each neuron in this layer transmits external signals directly to the next layer. That is,

$$y_i^{(1)} = x_i^{(1)}$$

(1)

Layer 2

This layer is called as the fuzzification layer. In this layer neuron receives an input and determines the degree to which this input belongs to the neuron's fuzzy set. The graph below shows the membership function for tall[7].
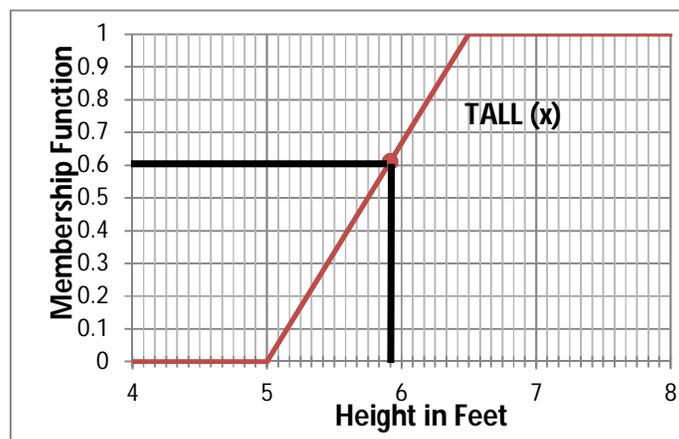

Figure 3: Example of Membership function

Layer 3

This layer is called as the Fuzzy rule layer. In this layer the fuzzification neurons that represent fuzzy sets neuron receives inputs. In a neuro-fuzzy system, the product operator is used for intersection. The if-then rules are like as follows [7]:

If X1 is A1 AND X2 is A2 AND…AND Xn is An
Then Y= min (W1X1, W2X2….WnXn)

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Thus, the output of neuron i in Layer 3 is obtained as:

Layer 4

This layer is called the output membership layer. Neuron in output membership layer combines all its inputs by using union operation. And probabilistic OR is used for this operation implementation. That is [7],

$$\mu_{C1}=max(\mu_{R1} w \oplus \mu_{R2} w \oplus \mu_{R3} w \oplus \mu_{R4} w \oplus \mu_{R5} w \oplus \mu_{R6} w) \qquad (2)$$

As shown μ_{C1} in above equation represents fuzzy rule neurons's strength.

Layer 5

This layer is called as the de-fuzzification layer. Neuron in this layer consists of a single output. Input in this layer is the output of the output membership and then combines this output to get the single output. There is standard method for de-fuzzification, a centroid method. Where μ_{C1} and μ_{C2} are the neurons in output membership function layer and y_1 and y_2 are the centroids, and it is calculated as shown below [7],

$$y = \frac{\mu_{c1} \cdot y_1 + \mu_{c2} \cdot y_2}{\mu_{c1} + \mu_{c2}} \qquad (3)$$

2.2 Weight optimization using Genetic Algorithm

Genetic algorithm is use to improve the learning of the neuro-fuzzy system which makes the training fast and also enhance its performance, because Genetic algorithms is commonly used for better solution due to its operator like selection, crossover and mutation. This system uses back-propagation algorithm for learning and training the neural network, but there are two major disadvantages with back-propagation algorithm. First is that the initialization of the NN weights is a blind process hence it is not possible to find out globally optimized initial weights and there is a danger that the network output would run towards local optima hence the overall tendency of the network to find out a global solution is greatly affected[3]. The second problem is that back-propagation algorithm is very slow in convergence and there is a possibility that network never converges [9]. This problem of local optimum solution can be solved by optimizing the initial weights of neural network. For this we use a genetic algorithm which is specialized for global searching. The backpropagation algorithm will be used to train the networks using the weights optimized by GA.

Here the combination of selection, crossover, and mutation operators by GA for finding out the best solution to a problem until the certain criterion is met [5]. In hybrid neuro-fuzzy genetic applications the GA creates an initial population according to the fitness function. The individual patient called a chromosome and by combining the chromosomes which is fittest according to fitness function makes initial population. A fitness function is needed in the Genetic Algorithm to evaluate whether an individual is "fit" to survive.

The principle is that individuals with high classification accuracy and small number of features has a high fitness value, and thus high probability to be pass its genes to the next generation[4]. A single objective fitness function that combines the two goals into one was designed to solve the multiple criteria problem. The formula is as below [6],

$$\text{Mean Square Error} = \frac{\sum (\text{Outputs- Targets})^2}{\text{Number of samples}} \qquad (4)$$

Selected chromosomes are subjected to mutation and to crossover. In some situation the crossover operator alone would not bring any changes and the search for an optimal solution would be ended for that purpose mutation is performed there for better result.

Steps for Genetic Algorithm are [4]:

a) Create the initial population according to Mean square error (fitness)
Fitness =1/MSE   (5)

b) Select two parents' chromosomes from a population according to their fitness.

c) Crossover with a crossover probability of parents to form new offspring.

Parent 1 :   <u>00101001|1</u>   0101001010101110

Parent 2 :   01010111|0   <u>1010101101110101</u>

Child   :   001010011   1010101101110101

d) Mutate new offspring randomly at any point.

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e) Compute the fitness of parents and child.

f) According to the fitness of one of the parent is replaced by child.

g) Accepting place new offspring in the new population

End

Genetic algorithm from this generates new input. Store the best feature for diagnosis of disease. Test the data to diagnose the optimum value.To get more reliability, the back propagation network has been initialized with optimized weights. Thus a Genetic Neuro Fuzzy System has been developed in which the Genetic Algorithm has been used for optimizing the initial weights of Neuro Fuzzy System.

3. CONCLUSION

In this paper application of a combined neuro-fuzzy genetic approach is proposed to predict the cardiovascular disease. The objective of the work is to predict chances of cardiovascular disease. The proposed work also helps to make system more accurate and efficient. With the help of genetic algorithm error rate is reduce and implementing the combination of neuro-fuzzy system will increase the classification performance and accuracy.

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